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An Analysis of Architectural Characteristics of an Aquarium from Bionic Design Approach

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Abstract

From the very beginning, man has spent so much effort on discovering the nature in this unknown territory, and to extract art and technology from nature and after realizing its values, reuse them in different forms and shapes. Therefore, it is necessary for him to make the connection among machine and living systems. One of the main trends in bionic design is to enliven the building. To achieve this purpose, direct or curve lines and attributing the integrity to the building are essential elements for reviving the buildings. Bionic buildings such as aquarium are open to publics in order to show aquatic organism. Majority of public aquariums contain different species. After world's creation, nature, itself, has turned into a good source of inspiration for designers and architects and during this time, plants and animals could cope with environmental issues through decoration and designing. They have also been trying to be inspired by nature and its surroundings for making needed equipment.

Keywords: aquarium, bionic, form, function

Introduction

Bionic facilities such as public aquariums are aimed to be used as recreational and entertainment centers. Places like aquarium, museums and can attract visitors' attention. For an example, some of the aquariums such as Monterey aquarium have low depth tank, filled with the variety of fish that can be felt and seen while people passing the tank.

Figure 1. Monterey aquarium

Aquariums such as zoos have research centers that help staffs study biology and fish behavior. In recent years, huge aquariums have intended to provide ocean fish and even crystal jelly for the tanks. It seems to be a difficult task as these creatures have never faced with a solid surface such as tank walls and instinctly they go through the walls rather than passing them. Therefore, bionic shapes can help designer create a real world. Nowadays, there are so many aquariums around the world, built based on bionic principles to prepare a comfortable atmosphere for its creatures. It has been a while that simple, solid and lifeless cubes as an aquarium cannot be a good model for contemporary architecture.

Bionic is an interdisciplinary field and it gathers designers, psychologists, environmentalist and engineers. Bionic is not restricted to a specific field and it can be expanded broadly. It analyzes a living mechanism in a way that can be applied in other man-made equipment. If bionic intends to collect information from diverse fields, it needs to define a new language in order to help different fields with understanding the potential environment and nature.

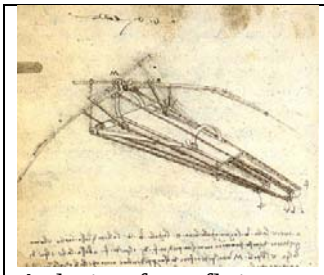
Literature Review

The world "bionic", used firstly by Jack E. Steele (January 27, 1924—January 19, 2009) an American and retired US Air Force colonel. He coined the world bionic for the systems with a living creature or its characteristics. Bionic has consisted of two words biology and technique, meaning to apply biological solutions for the engineering issues. (Hamoule Shalali. 2013, 16)

Bionic is the essence and foundation of all living microorganisms but by more attention, any industrial phenomenon and building are inspired by the nature. Now, bionic is playing an important role for applying biological systems in technical issues. The combination of two worlds' biology and technique introduce bionic design as a science that can be useful for solving technical issues (Rajabi Fard, 2008)

Bionic Architecture

From the very first, human being was inspired by nature and environment. For example, Leonardo da Vinci, was stimulated by the body of bats in order to make flying machine and the high-speed dolphins were good sources for submarine and even spider's web was applied for Montreal expo by Frei Otto, the German architect (URL : 35).



A design for a flying machine

Dance of dolphins

Expo 67

Figure 2. Sample of Bionic Architecture

Sometimes architecture is an artificial life, a science, taking place based on genetic and biological principles. Bionic and organic concepts were one of the major trends in twenty century and can been seen in works of le Corbusier, Wright and Sullivan.

Nature eliminates whatever is not adaptable and it can help human being study the process of evolution, copy the new microorganism and apply them into industry. Bionic architecture denies regulated and traditional forms. As a result, bionic encourages biological and mathematical buildings (Rajabifar. 2009,94).

When animals are analyzed, it is often difficult to extract them into micro and macro details. Even if, we fulfill this aim, it is not possible to examine animals because any creature has limited needs. For instance, its temperature does not change. Apart from this, a system of a living creature is very complicated. To tell more, in human being eyes, there are more than ten million cells in cornea that are connected to brain by nerve fibers. Brain has millions of these cells itself and it is going to be very sophisticated if scientists once spend time on analyzing this system.

Some scholars presents bionic as three important branches of science. In fact, there are important factors in the nature and human being use them wisely such as shell, structure, decoration, and energy

Bionic has created some interdisciplinary fields such as **morphology** (the scientific study of the structure and form of either animals and plants or words and phrases), **biomorphic** (Bio-morphism creating artistic artifacts based on naturally occurring patterns or shapes of nature and living organisms. Taken to its extreme, it attempts to force naturally occurring shapes onto functional devices.), **bio design** (Bio-Design is the integration of design with biological systems, often to achieve better ecological performance.) and organic (not using artificial chemicals in the growing of plants and animals for food and other products)

Furthermore, Bionic has three components:

1- The science of systems that has been inspired by micro-organisms (main structure)

2- The science of systems that have similar characteristics to micro-organisms (mechanism)

3- The science of systems that are resemble micro-organisms.(sensory reception)

In fact, the three main elements have structure, mechanism and form and functional relation with form and material are followed as below:

Color Analysis

Color is categorized by nerve cells in cornea. It seems that cells behaviors toward colors are exactly cells behavioral to shapes. All living creature can perceive colors but apparently just human being and monkeys can perceive all detailed changes in colors.

- The relationship between living creature's color and environment
- The relationship between living creatures' with behavioral feature and color
- The relationship between living creature's color and its body

An analysis of main elements of living creature and its usage in design

Form Analysis

An advanced construction can help us design anything that designers conceive. Our access to tools and, of course, technology had made complicated forms created easier but the question is whether these forms are following functions or vice versa. Structural specialists claim that form should be given the second priority as structure is an essential element while formalists believe that the progress in technology leads up to different and diverse form and as a result the beauty had become an important part of each form. However, it is necessary for us to know that form and function in bionic are closely related with each other and what seems important is how to connect these two key elements parallel.

- Basic form: points, faces
- Complicated forms:
- Formal combination
- Determination of proportions and dimensions
- Determination of the effects of curviness
- Determination of angles among lines

Analysis of Mechanism

The exact imitation is not a simple task. For instance Clement Ader (Clément Ader (2 April 1841 – 5 March 1925) was a French inventor and engineer was inspired by bat but he could not copy the exact mechanism. He was a great thinker and decided to study on birds' flight for a long time. He observed flying and convinced himself that there is no way for moving the machine's wings. He also realized that changing scale can drive him to a big failure and as a result he came up with using

propeller. The same strategy should be applied in bionic. The exact imitation is not what we are looking in the nature but awareness of the mechanism and its function is the a key element

- Simple mechanism
- Systematic relationship among mechanism
- Analysis of relationship among form with system and in reverse with form
- Analysis of relationship between form and function and vice versa
- Analysis on relationship between form and function and vice versa
- Analysis of relationship between systems and function and vice versa

The procedure of bionic design is as follows:

- Choosing living animals
- Recognition of behavioral inhabitant

Recognizing architectural features

In order to recognize architectural features, there are two main features:

- Internal features
- Systematic relationship
- Main physical body: micro elements and geometrical proportions, micro elements, material (Hamoule shalali, 2013, 25)

Bionic Architecture in Aquarium

Two decades ago, with increasing power in technology, Greg Lynn could ascribe new features to architecture. Their tools were new generation of computers that make them able to create mathematically complicated forms, non-geometrical forms and stimulation of micro-organism. Lynn is pioneer of giving a creative role to computer. Computer helps designers create new forms.

One of the famous works of him is Embryological House. In this concept, he is dealing with diversity, flexibility mass production. In this house, geometrical regulations have been defined perfectly and it proves that proportion, aesthetic, functions in its classic definition are valuable. Not only, does Embryological House influence by preliminary data, also it adapts itself with common local style, climatic condition and material. (Rajabifar, 2009, 97)

Figure 3. Embryological House

If a creature can adapt itself with different climatic conditions, new and different diets and even physical structures can be established, why cannot architecture do it?

Pioneers of bionic architecture

Leonardo da Vinci was one of the well-known architects who started discovering animals' structures. Charlie Luxton opened new windows toward the nature and helped us with understanding the quality of engineering system of the nature. Jan Kaplický has designed the form of The Selfridges Building in the Bull Ring in Birmingham. This building consisted of external and internal shells. The external shells have 15000 aluminum discs. The holes on exterior surface have the minimum holes and are similar to Commercial building in (Selfridges)

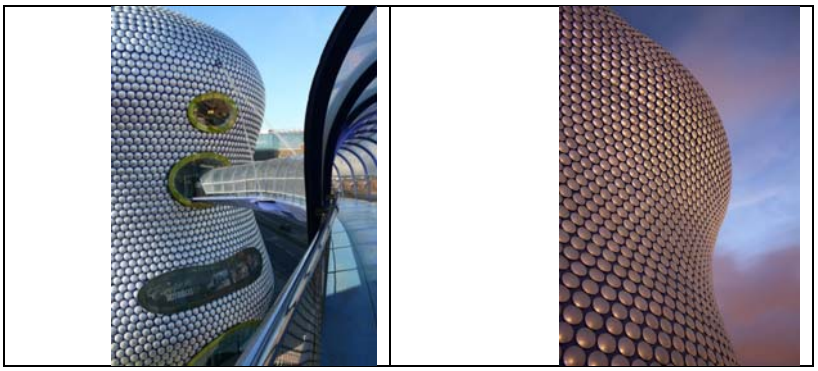


Figure 4. A sample of external and internal shells

Aquarium from Bionic approach

Public aquariums are public places with small tanks or bigger ones that can keep aquatic specious safe. After decades, aquariums have changed significantly in such a way that visitors can be an important part of space.

Table 1. The comparison between old and new aquarium

New models of aquarium (bionic based)	Old models of aquarium (none bionic based)
Visitors are part of nature	visitors are seeing nature
Active visitors	Passive visitors
Discovery learning	Educational method
ecosystem	Natural inhabitant
Related galleries	Discontinued spaces
flexible	Fixed
From noisy spaces to silence	Noisy
Calling for action	Accidental
Continuous exchange	Experimental
Related institute	Detached exhibition

Public aquarium has increased their functions and they are not just for displaying aquatic creature. But, they have educational purposes rather than entertainment. Bionic design can create this opportunity for visitors to perceive the vision, movement, group habit, behavior of aquatic creature.

Conclusion

Bionic design was born since the human beings' life and for centuries is the main source of inspiration for mankind. Nowadays, from the warmest to the coldest part, the trace of bionic design can be tracked down Bionic designed aquarium is known as artificial life.

Any kind of proper architecture that has been based on strong theory remains as scheme or a model.

However, for producing some themes such as aquarium, designers should consider the unique nature of these models according to the real model in the nature. As sometimes, making aquariums are complicated and they need high-technology,it is hard to artistically evaluate the innovation and creativity from technology.

Therefore, bionic design at the beginning was in the grip of new style-fever and was not popularized but when first steps were taken strongly, it came as a surprise that nature is a pure and intact source of inspiration.

Bionic is a science of some systems that are similar to living systems and in another word imitation is the first step for discover the nature. In this field, systems have resemblance to living creature with respect to evolutions. Life does pause and it goes on in any stage. But, the assessment and evaluation of the nature is the key responsibility of the designer as he is supposed to ask himself weather this way can advance or it should return the beginning step.

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